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Intelligence in early adulthood and subclinical atherosclerosis in middle-aged men: the Vietnam Experience Study

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Abstract

Background: People with higher intelligence in early life have a lower subsequent risk of coronary heart disease events, but the explanation for these observations is unclear. We examined whether intelligence in early adulthood was associated with risk of subclinical atherosclerosis in mid life, as indicated by the ankle brachial index (ABI), and investigated its potential mediating role in the association between intelligence and mortality.

Methods: Participants were 4286 male US veterans whose intelligence was measured on enlistment into military service at a mean age of 20.4 years and whose ABI was measured by Doppler as part of a detailed medical examination at a mean age of 38.3 years.

Results: Higher intelligence in early adulthood was associated with a higher ABI in mid life. For a standard deviation increase in intelligence, after adjusting for age, ABI (x 10) rose by 0.05 (0.02, 0.07), and the odds ratio (95% CI) for having a low ABI ($\leq$0.90) was 0.84 (0.72, 0.98). Further adjustment for smoking, serum cholesterol, triglycerides and glucose concentrations, blood pressure, erythrocyte sedimentation rate, body mass index, alcohol intake, education and measures of socioeconomic position had little or no attenuating effect on these associations. Lower ABI was associated with increased mortality from all causes and cardiovascular disease but it did not account for the associations between IQ and mortality from these causes.

Conclusions: Men of lower intelligence may be more susceptible to atherogenesis, though this mechanism does not appear to explain their increased risk of earlier death.

Introduction

People who score higher on tests of cognitive ability in childhood or adolescence have a lower risk of coronary heart disease events in later life.[1-5] The explanation for these findings is unclear. Although a few studies have been able to examine the potential mediating role of some established risk factors, they appear to account for very little of the association.[6]

Ankle brachial index (ABI)—the ratio of systolic pressure at the ankle to that in the arm—is used to assess peripheral arterial disease in the legs, but it is also an indicator of generalised atherosclerosis. Lower ABI is linked with higher concurrent levels of atherosclerotic disease in other parts of the arterial tree[7] and is a powerful predictor of cardiovascular events.[8] To our knowledge, the relation between intelligence in youth and risk of subclinical atherosclerosis later in life has yet to be examined.

The Vietnam Experience Study is a large, longitudinal study of male US veterans who completed tests of intelligence on enlistment into military service and underwent a detailed medical examination in middle age. In the first such study of which we are aware, we used these data to examine the relation between intelligence in early adulthood and the ABI in mid life. We also investigated its potential mediating role in the association between intelligence and mortality.

Methods

The Vietnam Experience Study was conducted by the US Centers for Disease Control. Ethical approval for the study protocol was given by the US Office for Technology Assessment, the Department of Health and Human Sciences Advisory

Committee, the Agent Orange Working Group Science Panel, and a review panel from the US Centers for Disease Control. Participants were identified retrospectively using military records, as described elsewhere.[9,10] The flow chart in Figure 1 shows the sampling at each stage of the study. In brief, 18,313 former military personnel were drawn randomly from approximately five million US army veterans who had served in Vietnam and elsewhere and whose service files were stored at the National Personnel Records Center. Information on place of service, rank, ethnicity and cognitive ability were extracted from military archives. Based on rank at army discharge (mean age 22.5 yr., range: 17.9 to 36.8), monthly income according to 1964 pay scales was derived. Ethnic origin was classified as 'white', 'black', or 'other'; the latter group comprising Hispanics, Asians, Pacific Islanders, American Indians, and Alaskan Natives.

On enlistment, participants took a general aptitude test: the General Technical Section of the Army Classification Battery. [11] This consists of two subtests, verbal and arithmetic reasoning. Scores on the General Technical Section correlate highly with scores on standard tests of intelligence.[11] For ease of interpretation, we converted total scores on the General Technical section to an IQ equivalent (mean 100, SD 15).

Of 18,313 former military personnel who qualified for inclusion in the original study cohort, 446 died post-discharge. The remainder (N=17,867) were considered to be alive on December 31st 1983 and eligible for follow-up through interview and examination. In all, 15,288 men (85.6% of target population) participated in a telephone survey in 1985-6 during which they provided information about lifestyle and socioeconomic characteristics (household income and years of completed education).

In 1986 a random sample were invited to a detailed medical examination; 4462 attended (69.3% of those invited). Participants signed a consent form on the first day. Blood pressure was measured twice in the right arm while the participant was seated using a sphygmomanometer and an average computed. Fasting blood samples were taken for assessment of serum triglycerides, cholesterol, glucose, and erythrocyte sedimentation rate, and height and weight were measured, from which body mass index (BMI, kg/m^2) was calculated. Levels of triglycerides and cholesterol fractions were ascertained using a Kodak Ektachem 700 AutoAnalyzer (Eastman Kodak, Rochester, New York). [12] Serum glucose level was determined with an adaptation of the glucose oxidase-peroxidase-chromogen-coupled system for glucose determination in biological fluids.[12] ESR was measured using the Westergen method. Briefly, venous blood was mixed with an aqueous solution of sodium citrate and the mixture allowed to stand in an upright standard pipette for an hour, following which the number of millimetres the cells had descended was measured.

We defined the metabolic syndrome and its components using a modified version of the Adult Treatment Panel III recommended diagnostic criteria.[13] According to this definition, participants were classified as having the metabolic syndrome if any three of the following were present: BMI $>$ 30 kg/m^2 (in the absence of data on waist circumference, BMI at this threshold is regarded by the WHO as an acceptable substitute in defining the metabolic syndrome[14]); fasting plasma glucose ≥6.1 mmol/l (110 mg/dl) or medication for diabetes (as reported at the medical examination);

triglycerides ≥1.7 mmol/l (150 mg/dl); HDL-cholesterol level <1.036 mmol/l (40 mg/dl); and blood pressure ≥130/85 mmHg and/or use of antihypertensive medication.

Men underwent an examination of the peripheral arterial system with a Model 1010-LA Dual Frequency BiDirectional Doppler (Parks Medical Electronics Inc, Beaverton, OR). The examinations were carried out by trained technicians using a standardized protocol, supervised by a physician. Men were requested not to smoke, consume caffeine-containing drinks or exercise for 1 hour before being tested. Right and left brachial blood pressures were taken, with the participant supine, using the Doppler technique. An occluding cuff was placed round the arm. The brachial artery was palpated in the antecubital fossa, the pulse located using the Doppler probe and the cuff inflated until the pulse was no longer detectable. The cuff was then slowly deflated and the pressure noted when the pulse reappeared. Right and left supine ankle pressures were then measured in a similar way. The cuff was placed around the ankle with the lower edge just above the malleolus. The Doppler transducer was placed over the posterial tibial and/or dorsalis pedis artery. The vessel with the strongest Doppler signal was chosen. ABI for each leg was calculated by dividing the ankle systolic pressure by the higher of the right and left brachial systolic pressures.

As part of the data quality assessments, repeat examinations were carried out in a random 4% sample (n=159) by a second technician who was unaware of the results of the first examination or the veterans' place of service. The intra-class correlation coefficients (a measure of agreement between the paired observations) for Vietnam-serving and non Vietnam-serving veterans respectively were as follows: right ankle blood pressure 0.76 and 0.74; left ankle blood pressure 0.73 and 0.77; right brachial pressure 0.60 and 0.61; left brachial pressure 0.78 and 0.74; right ABI 0.17 and 0.42; left ABI 0.13 and 0.35. There were no statistically significant differences in interobserver variability by veterans' place of service in any of these measurements.[15]

We used the lower of the left and right leg indices in the analysis as indicative of worse disease. Low ABI was defined as ABI ≤ 0.9, consistent with most recent studies.[8,16] Men with an ABI >1.4 (n=6) were excluded in case arterial stiffness had produced falsely high levels.

Participants were followed up for mortality for 15 years after the examination, as described previously.[9]

Statistical analyses

We used ANOVA and correlation coefficients to examine the relations between intelligence, ABI (as a continuous variable) and other characteristics. Spearman correlations were used instead of Pearson correlations for characteristics that were categorical or had a skewed distribution. Point bi-serial correlations were used for binary variables. We used linear and logistic regression to examine associations between intelligence and ABI (as a continuous and a binary variable), with adjustment for potential confounding or mediating variables. We used Cox proportional hazards models to examine the potential mediating role of ABI in previously demonstrated associations between intelligence and total and cardiovascular mortality (ICD codes 390–434 and 436–459 (version 9) and I00-I99 (version 10)).

Results

Characteristics of the 4286 men with complete data on IQ, ABI and covariates are shown in Table 1. Their age range at examination was 31-48 years. Comparison of the early adult characteristics of these men with those who were originally enrolled to take part in the study but were excluded from the present analyses (n=11, 002) because they were not randomly selected to take part in the medical examination, or had incomplete data, showed no difference between the two groups in army income, ethnicity, age at enlistment, or place of service (data not shown), but IQ was very slightly higher in the analytical sample: mean (SD) 101.3 (15.2) vs 100.2 (14.9), $p<0.001$. The fact that this marginal difference was statistically significant can be ascribed to the large sample size.

ABI was normally distributed with a negative skew. Mean (SD) ABI was 1.12 (0.09). In total, 161 (3.8%) men had an ABI ≤ 0.9. Men with a lower IQ at enlistment had a lower ABI at examination ($r=0.07$, $p<0.001$). Lower ABI was also associated with higher blood concentrations of total cholesterol ($r=-0.05$, $p=0.002$) and glucose ($r=-0.08$, $p<0.001$), higher erythrocyte sedimentation rate ($r=-.07$, $p<0.001$), higher diastolic blood pressure ($r=0.05$, $p=0.003$), higher alcohol intake ($r=-0.06$, $p<0.001$), being a smoker currently ($r=-0.11$, $p<0.001$), lower educational attainment ($r=0.07$, $p<0.001$), and lower household income ($r=0.04$, $=0.008$). Men who were older at the time of enlistment – probably due to taking college deferments before entering the military (age at enlistment was positively correlated with educational attainment ($r=0.29$, $p<0.001$)) – tended to have a higher ABI ($r=0.06$, $p<0.001$). Lower ABI was weakly associated with the presence of the metabolic syndrome ($r=-0.04$, p=0.02), but examination of the individual components of the syndrome showed that this association was driven by the link between lower ABI and high blood glucose; there were no statistically significant associations between ABI and having low HDL cholesterol, high triglycerides, hypertension, or being obese. There were no associations with ABI when BMI, triglycerides, HDL cholesterol or systolic blood pressure were analysed as continuous variables. ABI did not vary significantly according to ethnicity, place of service or army income.

Table 2 shows the relation between IQ scores at enlistment and the covariates. Men with higher IQ scores were more likely to be white, to have a higher income during army service and currently, to have served in the US rather than Vietnam, and to have higher educational attainment. They were less likely to be current smokers or heavy drinkers and to meet criteria for the metabolic syndrome. Higher intelligence was also associated with older age at examination, lower systolic and diastolic blood pressure, lower blood concentrations of total cholesterol, triglycerides and glucose, a lower erythrocyte sedimentation rate and a lower BMI.

Table 3 shows regression coefficients (95% CI) for the change in ABI and odds ratios (95% CI) for having a low ABI (≤ 0.9) per SD increase in intelligence at enlistment, first unadjusted, then with adjustment for age, and with further separate adjustment for potential confounding or mediating variables. For a standard deviation increase in intelligence at enlistment, after adjusting for age, ABI (x 10) rose by 0.05 (95% CI 0.02, 0.07), and the odds ratio (95% CI) for having a low ABI (≤0.90) was 0.84 (0.72, 0.98). Of the cardiovascular risk factors, adjustment for smoking and erythrocyte sedimentation rate had the largest effects, each reducing the regression coefficient by

21%, but the association remained significant. The inclusion of education and household income also had some attenuating effect, but in general further separate adjustment for other characteristics had little or no effect on the association between intelligence and later ABI.

When we replaced the continuously distributed covariates of total cholesterol, HDL cholesterol, triglycerides, glucose and BMI with variables dichotomized according to clinical definitions (total cholesterol >6.2 mmol, HDL cholesterol <1.04 mmol/l , triglycerides $\geq$1.7 mmol/l, glucose $\geq$6.1 mmol/l , BMI >30 kg/m^2), estimates for the relation between IQ and ABI were unchanged from those shown in Table 3 (data not shown).

During the follow-up period 237 men died, 63 from cardiovascular disease. Men with a lower ABI had an increased risk of death. For an SD decrease in ABI, the age-adjusted hazard ratio (95% CI) was 1.25 (1.11, 1.42) for all causes, and 1.33 (1.05, 1.68) for cardiovascular disease. Table 4 shows the age-adjusted hazard ratios for all cause and cardiovascular mortality according to intelligence at enlistment, before and after adjustment for ABI in mid life. Higher intelligence was associated with lower mortality: the age-adjusted hazard ratios per SD increase in IQ were 0.71 (0.63, 0.81) for all causes and 0.75 (0.59, 0.96) for cardiovascular disease. However, adjustment for the potentially mediating effect of ABI, had almost no effect on these estimates, changing them to 0.72 (0.63, 0.82) and 0.76 (0.60, 0.97) respectively.

Discussion

To our knowledge, this is the first study to link intelligence prospectively with a measure of subclinical atherosclerosis. A small study in elderly people found that men with higher peak prior intelligence had a lower mean carotid IMT and a reduced risk of carotid stenosis,[17] but the cross-sectional design of the study made it hard to draw firm conclusions about the direction of effect. Our finding that men who gained higher scores on a test of cognitive ability in early adulthood have a reduced risk of having a low ABI in mid life suggests that higher intelligence or an associated variable may protect against atherogenesis.

Previous studies using these data showed that when followed up in mid life, men with higher intelligence in early adulthood were less likely to be a current smoker or binge drinker, had lower fasting blood concentrations of glucose and total cholesterol, a lower BMI[18] and lower levels of the inflammatory marker, erythrocyte sedimentation rate.[19] These observations are consistent with findings in some other cohorts linking higher intelligence with a more favourable cardiovascular risk factor profile later in life, in terms of smoking,[20,21] blood pressure,[22,23] and BMI.[23-25] Smoking habits and systemic inflammation, as indicated by erythrocyte sedimentation rate, appeared to provide a partial explanation in the present study for the link between intelligence in early adulthood and subsequent ABI, but adjustment for a range of other cardiovascular disease risk factors had little or no effect on the strength of association. Adjustment for educational attainment and income in mid life had some attenuating effect but as intelligence is likely to have had a strong influence on educational attainment, and hence socioeconomic position, adjustment for this may be inappropriate.

Although we were able to examine the part played by a number of established cardiovascular risk factors in the link between intelligence and later ABI, our information on inflammatory factors was limited to a single marker, erythrocyte sedimentation rate. We were not able to examine the potential mediating role of other factors that promote hypercoagulability or thrombosis. Individuals with lower ABI have been shown to have higher levels of several hemostatic and inflammatory markers.[26,27] Recent evidence suggests that poorer intelligence in youth may be predictive of higher levels of the markers c-reactive protein and fibrinogen later in life.[28]

There are other mechanisms that might potentially help to explain the link between intelligence and later ABI. There is some evidence that men with lower intelligence in childhood have poorer renal function in later life.[29] Data from several large studies, including the Atherosclerosis Risk in Communities Study and the National Health and Examination Survey, show that adults with poorer renal function have an increased risk of peripheral arterial disease.[30,31] Furthermore, findings from one of the UK's national birth cohorts indicate that higher intelligence in youth is associated with healthier behaviour in adulthood as regards diet and physical activity,[32] both of which may play a part in atherosclerotic disease.[33] We lacked the data to explore whether these mechanisms might play a part in the association between intelligence and later ankle brachial index.

A low ABI was associated in this study with most established cardiovascular risk factors and was strongly predictive of death both from all causes and cardiovascular disease, confirming its value as a marker of generalized atherosclerosis. Although lower intelligence was also associated with increased mortality from these causes, this did not appear to be accounted for by atherosclerosis, at least as indicated by ABI in mid life. We had no data on ABI at the time intelligence was measured in early adulthood so we were not able to examine change in ABI over the approximately 17-year period that elapsed between enlistment and the follow-up examination. It is possible that this might have provided a more reliable assessment of the potential mediating role of subclinical atherosclerosis in the early adult intelligence-mortality association than our single measure of ABI in mid life, though it is worth noting that little is known about the validity of the ABI at younger ages.[34]

Few previous studies have been able to examine the extent to which cardiovascular disease risk factors account for the link between intelligence in youth and mortality in later life. In earlier investigations using this cohort, the behavioural risk factors smoking and alcohol consumption appeared to play only a minor role, attenuating the association between intelligence and all cause mortality by less than 18% and that between intelligence and cardiovascular disease mortality by around 16%.[6,18] Physiological risk factors, including blood pressure, lipid and glucose concentrations, and BMI, seemed to play a greater role in the link between intelligence and mortality from cardiovascular disease, attenuating the association by around 44%,[6] but to have a negligible effect in the case of all cause mortality.[18] In contrast, adjustment for markers of socioeconomic position in adult life, such as education and income, severely attenuated both associations,[6,18] though interpretation of this effect is complex because it remains unclear whether these adult socioeconomic indicators are mediators or confounders of the intelligence-mortality association or partial surrogates for intelligence.

The strengths of this study include its large sample size and the fact that the measurement of intelligence preceded that of ABI. As intelligence was measured in early adulthood it is unlikely that the apparently protective effect of a high IQ score is due to reverse causation in which peripheral arterial disease increases the risk of cognitive decline.[35] However, as we had no data on ABI at the time intelligence was measured, we cannot be certain that our finding of a link between early adult intelligence and mid life ABI indicates a potential effect of intelligence on progression of atherogenesis. It is possible that men with lower intelligence at enlistment already had a lower ABI, and the association between IQ score in early adulthood and ABI in mid life is primarily a reflection of this. Our study also has some other weaknesses. The sample consists of army veterans, all of whom would have been required to meet the army's minimum physical fitness requirements at the time of enlistment. As an occupational cohort, our sample is likely to be healthier than the general population of the same age and sex as individuals with severe illness or disability will not have been selected for army service. Comparison of mean levels of selected physiological risk factors in the men in our sample with those obtained from men of a similar, but not identical age range, in the second National Health Nutrition and Examination Survey (1976-80) suggest that the men in our sample have slightly lower systolic blood pressure[36] and a lower prevalence of obesity,[37] but differ little as regards total or HDL cholesterol.[38] We have no means of knowing whether our sample differed in mean IQ scores from the national population of men of this age, but it is likely that men with the lowest scores will be under-represented because the test taken during selection for the army was designed to detect intellectual deficits.[11] Other limitations of our study are that the sample consisted of men only and, in common with most previous research that has been carried out on the relation between intelligence and later health, it was drawn from a western, developed population. It is unclear whether these results would apply to women or to populations from less developed countries. Furthermore, results of the repeat testing carried out in a random sample of participants by the original Centers for Disease Control investigators suggest that the reliability of ABI measurements was low. This means that the associations described here between ABI and other characteristics, including intelligence, may be a considerable under-estimate of the true associations. It is worth noting, however, that this repeatability study had a serious limitation in that it was based on second observations by only one technician. The prevalence of low ABI in these male veterans at 3.8% was similar to the prevalence of around 3-5% observed in men aged <50 in population studies from Belgium, Netherlands, Germany and Spain,[39] suggesting that the measurement had some validity.

In summary, we have shown that lower intelligence in early adulthood is associated with an increased risk of subclinical atherosclerosis, as measured by lower ABI, in middle-aged men, but ABI did not account for the link between lower intelligence and mortality. The association between intelligence and ABI was modest in size and its clinical significance is uncertain. Future research will need to replicate our observation that men of lower intelligence may be more susceptible to atherogenesis, to investigate the wider range of physiological mechanisms that might underlie this finding and to explore factors in the psychosocial and physical environment in childhood that affect both intelligence and cardiometabolic profile.

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Figure legend:

Figure 1: Sampling of the participants

Table 1: Characteristics of the men in the study (n=4286)

Data recorded at baseline	
Ethnicity, no (%)	
White	3510 (81.9)
Black	503 (11.7)
Other	273 (6.4)
Place of service, no (%)	
Vietnam	2370 (55.3)
Other overseas	1104 (25.8)
US	812 (18.9)
Army income (US$/week), no (%)	
83-119	534 (12.5)
120-144	2118 (49.4)
145	1634 (38.1)
IQ at enlistment, mean (SD)	101.3 (15.2)
Data recorded at follow-up	
Education (grade completed), mean (SD)	13.3 (2.30)
Household income (US$/yr), no (%)	
<20,000	1217 (28.4)
-40,000	2141 (49.9)
>40,000	928 (21.7)
Smoking status, no (%)	
Never	1091 (25.5)
Ex	1222 (28.5)
Current	1973 (46.0)
Alcohol intake (units per wk), no (%)	
None	1806 (42.1)
1-7	1329 (31.0)
8-21	813 (19.0)
>21	338 (7.9)
Age at examination (yr), mean (SD)	38.3 (2.52)
Total cholesterol (mmol/l), mean (SD)	5.50 (1.08)
Total cholesterol >6.2 mmol/l, no (%)	1045 (24.4)
HDL cholesterol (mmol/l), mean (SD)	1.15 (0.32)
HDL cholesterol <1.036 mmol/l, no (%)	1679 (39.2)
Triglycerides (mmol/l), mean (SD)	1.26 (0.94)
Triglycerides ≥1.7 mmol/l, no (%)	820 (19.1)
Glucose (mmol/l), mean (SD)	5.23 (0.94)
Glucose ≥6.1 mmol/l or on medication for diabetes, no (%)	221 (5.2)
BMI, mean (SD), kg/m^2	26.9 (4.48)
BMI >30 kg/m^2, no (%)	553 (12.9)
Systolic blood pressure, mm Hg	123.0 (12.0)
Diastolic blood pressure, mm Hg	84.1 (9.44)
Blood pressure ≥130/85 mmHg and/or on antihypertensive medication, no (%)	2284 (53.3)
Metabolic syndrome, no (%)	672 (15.7)
Erythrocyte sedimentation rate, mm/h	37.0 (17.3)

Table 2: IQ at enlistment in relation to the covariates (n=4286)

	Mean (SD) IQ score	P value[1]
Ethnicity		
White	103.9 (14.2)	<0.001
Black	87.7 (13.2)	
Other	93.4 (14.4)	
Place of service		
Vietnam	100.3 (14.7)	<0.001
Other overseas	101.7 (15.7)	
US	103.9 (15.4)	
Army income (US$/week)		
83-119	93.6 (13.8)	<0.001
120-144	99.2 (15.1)	
145	106.7 (13.9)	
Education (grade completed)		
≤11	86.7 (12.2)	<0.001
12	97.0 (12.0)	
>12	107.9 (13.9)	
Household income (US$/yr)		
<20,000	94.1 (14.7)	<0.001
-40,000	101.6 (14.0)	
>40,000	110.1 (13.4)	
Smoking status		
Never	104.0 (14.7)	<0.001
Ex	103.7 (15.4)	
Current	98.3 (14.7)	
Alcohol intake (units per wk)		
None	99.8 (15.7)	<0.001
1-7	103.8 (14.9)	
8-21	102.1 (14.9)	
>21	98.1 (14.2)	
Metabolic syndrome		
No	101.7 (15.2)	0.002
Yes	99.7 (14.9)	
	Correlation with IQ score	**P value**
Age at examination (yrs)	0.14	<0.001
Total cholesterol (mmol/l)	-0.04	0.010
HDL cholesterol (mmol/l)	-0.002	0.916
Triglycerides (mmol/l)	-0.05	0.003
Glucose (mmol/l)	-0.05	<0.001
BMI (kg/m^2)	-0.03	0.038
Systolic blood pressure (mm Hg)	-0.06	<0.001
Diastolic blood pressure (mm Hg)	-0.07	<0.001
Erythrocyte sedimentation rate (mm/h)	-0.18	<0.001

[1] P value for difference between groups

Table 3: Regression coefficient (95% CI) for change in ankle brachial index and odds ratio (95% CI) for having an ankle brachial index ≤0.9 per SD increase in IQ (n=4286)

	Regression coefficient (95% CI) for change in ABI x 10	**Odds ratio (95% CI) for ABI ≤0.9**
Unadjusted	0.06 (0.03, 0.08)	0.83 (0.71, 0.96)
Age-adjusted	0.05 (0.02, 0.07)	0.84 (0.72, 0.98)
Adjusted for age and each of the following:		
Ethnicity	0.05 (0.02, 0.08)	0.83 (0.71, 0.99)
Place of service	0.05 (0.02, 0.07)	0.84 (0.72, 0.98)
Army income	0.05 (0.03, 0.08)	0.84 (0.71, 0.98)
Education	0.04 (0.01, 0.07)	0.84 (0.70, 1.00)
Household income	0.05 (0.02, 0.07)	0.85 (0.72, 1.00)
Smoking status	0.04 (0.01, 0.07)	0.86 (0.73, 1.00)
Alcohol intake	0.05 (0.02, 0.07)	0.84 (0.72, 0.98)
Total cholesterol	0.05 (0.02, 0.07)	0.84 (0.72, 0.98)
HDL cholesterol	0.05 (0.02, 0.07)	0.83 (0.71, 0.98)
Triglycerides	0.05 (0.02, 0.07)	0.84 (0.72, 0.98)
Glucose	0.05 (0.02, 0.07)	0.85 (0.72, 0.99)
BMI	0.05 (0.02, 0.07)	0.84 (0.72, 0.99)
Systolic blood pressure	0.05 (0.02, 0.08)	0.84 (0.72, 0.98)
Diastolic blood pressure	0.05 (0.03, 0.08)	0.83 (0.71, 0.97)
Metabolic syndrome	0.05 (0.02, 0.07)	0.85 (0.73, 0.99)
Erythrocyte sedimentation rate	0.04 (0.01, 0.07)	0.85 (0.72, 0.99)

Table 4: Hazard ratios (95% CI) for all cause and cardiovascular disease mortality per SD increase in IQ, with adjustment for ankle brachial index (n=4286)

Adjustments	Hazard ratio (95% CI) for all cause mortality	Hazard ratio (95% CI) for cardiovascular mortality
Age	0.71 (0.63, 0.81)	0.75 (0.59, 0.96)
Age and ankle brachial index	0.72 (0.63, 0.82)	0.76 (0.60. 0.97)

What is already known on this topic?

People who score higher on tests of intelligence in childhood or adolescence have a lower risk of coronary heart disease later in life. The explanation for these findings is unclear

What this paper adds?

Men with higher intelligence in early adulthood have a reduced risk of subclinical atherosclerosis, as measured by the ankle brachial index. Lower ABI was associated with increased mortality from all causes and cardiovascular disease but it did not account for the associations between IQ and mortality from these causes.